



Resiliency Analysis for the Development of Microgrid Architecture against Climate- Driven Events in the Dominican Republic's Electric Systems

PEER ANNUAL REPORT
(15/04/2021 – 15/03/2022)



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Section 1: Financial Report

Partnerships for Enhanced Engagement in Research (PEER) Science: Annual Financial Report Form

Principal Investigator: Ramón Emilio De Jesús Grullón

Project Title: Resiliency Analysis for the Development of Microgrid Architecture against Climate-Driven Events in the Dominican Republic's Electric Systems.

Report Period: April 15-2021 through April 14-2022

Expense Category		Total in Approved Budget (Entire Project) USD\$	Total Spent in Report Period USD\$	Total Spent on Entire Project to Date USD\$
Travel	International travel	1,799.86	275.00	
	National travel	648.00	0.00	
Equipment and supplies		90,906.00	92,296.67	
Other direct costs (computer services, publications, workshops and conferences, etc.)		11,308.04	7104.24	
Salaries and stipends (including fringe benefits)		50,525.00	21,172.67	
Indirect costs		3,879.67	1939.84	
Totals		159,066.57	122,788.42	

In addition to completing the budget table, please provide the information requested below (expand the spaces as necessary).

1. Overall: Please explain any differences between actual amounts spent compared with amounts in your approved project budget and provide details on plans to make up the difference in the next year.



Financial Summary Year 1					
Budget Category	Approved budget Y1	Amount spent Y1	Difference	Explanation of Difference by Category	Final Balance
Travel	923.95	275.00	648.95	Amount partially used due to Covid-19 restrictions on national and international events.	648.95*
Durable Equipment	90,906.00	\$92,296.67	(1,390.67)	Unforeseeable-high fees for transportation services of some of the equipment from country of origin to Dominican Republic. Difference of USD\$1,390.67 covered by amount reallocated from Other Direct Cost, specifically from item 1.2 Working computers (USD\$1003.76) and from item 4. Spendable and Books (USD\$386.91).	0.00
Other Direct cost	9,036.57	\$7,104.24	1,932.33	Amount of USD\$1390.67 reallocated from Direct cost to Durable Equipment, as detailed above.	541.66*
Salaries	24,375.00	24,395.50	(20.50)	Fringe benefit (end of contract bonus) was not budgeted for the 3 months contract of the Research Assistant.	(20.50)
Institutional Indirect costs	1,939.84	1,939.84	-		0.00
Total USD\$	127,181.36	126,011.25	1,170.11		1170.11

-For more details, please see **Attachment 1: Financial Report by Category**.

* Unspent funds for categories Travel and Other Direct Cost are planned to be used during the project second year for the purpose of *International Travel and Workshop and conferences*, as both, events organized under the project and participation of team members in workshops and conferences, were restricted due to the pandemic.



2. Equipment: Please list and attach receipts for any pieces of equipment purchased that cost \$5000 or more. (It is not necessary to itemize less expensive pieces of equipment or consumable supplies purchased.)

Equipment Description	Quantity per item	Total cost in USD\$	Vendor selected	Receipts enclosed (Document number)
3KW PROGRAMMABLE DC POWER SUPPLY	1	5,700.00	REXGEAR, INC.	2239
OpalRT PHIL simulation system and required software	1	60,267.00	OPAL-RT TECHNOLOGIES	2258
Taraz equipment and required software	1	20,450.00	Taraz Technologies	2262
30KW AC Resistive Digital Electronic Load	1	5,498.70	TEQUIPMENT.NET	2289

3. International Travel: Please list the travelers' names, dates, destinations, and purposes of any trips charged to the grant during this reporting period.
Please itemize total USAID/PEER grant funds used, listing amounts in USD:

- a) Travel (Flight, transit cost);
- b) Participant cost (accommodation, meals),
- c) Instruction cost (registration fees, instruction supplies, etc.).

TOTAL:

If any non-USAID/non-PEER funds were used to supplement such international travel, please list the source of funding and itemize total non-PEER funds used in USD:

- a) Travel (Flight, transit cost);
- b) Participant cost (accommodation, meals),
- c) Instruction cost (registration fees, instruction supplies, etc.).

Also, please attach receipts for any international air tickets charged to the grant.

4. Salary: Please list the names of anyone who drew a salary or stipend from the grant, along with their job titles, role on the project, and amount charged. Your institution should retain full documentation on all such expenses for audit purposes.

Name	Job Title	Role on the project	Amount charged Y1-USD\$
Ramón Emilio de Jesús Grullón	Electromechanical Engineering B.S.; Renewables Energies and Electric Markets M.S,	Researcher (PI)	9,360.00
Abraham Espinal Serrata	Electromechanical Engineer B.S.; Master in Renewable Energy and Energy Efficiency M.E.	Researcher (co-PI)	9,360.00
Rafael Omar Batista Jorge	Electronic Engineer, B.S.; Control Systems M.E.; Biomedical Engineering MsC.	Researcher (co-PI)	4,680.00
Juan José Pichardo Estévez	Bachelor student	Research assistant	995.50
Total USD\$			24,395.50

Full documentation is provided in Attachment 2: Expense Report for Year 1 with corresponding proof of payments. Payments from March and April 2022 payroll for the project is pending.

Section 2 - Technical Summary

Q1 - Abril 2021 - Julio 2021

2.1 OpenDSS-Based Distribution Network Analyzer in Open Source GIS Environment Implementation in EDENORTE (VOLG101).

In order to assess and study the impact of Distributed Generation, and the design of Microgrid Architecture in the Medium Voltage (MV) and Low Voltage (LV) networks, it is necessary to have advanced simulation tools and detailed models of the Distribution Network and its components.

To make these simulations more flexible and accessible, open-source software tools such as OpenDSS (Open Distribution System Simulator) are now frequently used. Even though it is a script-based simulator with limited Graphical User Interface, it can be driven from other platforms (e.g. Python and Matlab) through the Component Object Model (COM) server.

With the goal of implementing and adding the OpenDSS-Based Distribution Network Analyzer into EDENORTE's (main stakeholder) software stack, a working group was created within the Distribution Management and Network Studies Department and the MG Research Team. The task at hand is to create a blueprint of the processes that are necessary *to obtain, clean and transform* the utilities' existing GIS Data to be fed into the QGIS2OPENDSS Plugin. Several *Data Dictionaries* and *Workflows* are being created in order to standardize and summarize the efforts that have been conducted for future use.

2.2 Matlab/Simulink® Model

Various research activities are being developed regarding the implementation of models for the evaluation of diverse indexes for the study of reliability and resiliency of the electrical grid. This research's first approach has been to study the actual structure of Dominican Republic's electrical grid to identify one critical feeder to proceed with the modeling of the dynamic response under fault conditions.

The selected critical electrical feeder is represented by the two main hospitals in the North Region of Dominican Republic and a commercial/residential electrical circuit with a high integration of renewable energy Distributed Generators (DG). Matlab/Simulink® environment has been selected for the creation of this electromagnetic transient offline simulation.

Ongoing research is being done with the objective of calculating the reliability and resiliency indexes. A simulation model for feeder protection relays is being constructed, in which a custom Simulink® model will determine if the protection relay is under trip condition and disconnect the selected feeder. This is critical for the calculation of resiliency indexes that are based on the number of loads that have been affected by a fault condition. At the same time, a more detailed model for the commercial/residential circuit under this feeder is under development, which will allow for the integration of the

DEG into the simulation and to observe the effect on fault currents these DEG may introduce.

Q2 - July 2021 - October 2021

2.3 OpenDSS-Based Distribution Network Analyzer in Open Source GIS Environment Implementation in EDENORTE (VOLG101).

In order to reduce complexity and to address the current challenges, while also testing the software capabilities and flexibility the selected distribution networks have been reduced significantly, but the simulations have been running flawlessly. A great deal of effort will be invested to fix the software bugs and to increase the simulation output which will allow for further automation. Automating the process allows for faster development on future stages of project development in the academic world and in terms of being able to transfer knowledge.

2.4 Indicative Plan for Critical Energy Infrastructure (Report for Vice Minister of Security and Energy Infrastructure)

The Vice Ministry of Energy Security and Infrastructure is a body of technical nature that is linked to the Ministry of Energy and Mines and is in charge of carrying out studies on energy security for the construction and protection of critical energy infrastructure related to the transportation, storage and refinement of fuels, as well as gas pipelines, oil pipelines, and electric networks.

Currently, the energy sector in the Dominican Republic faces great challenges due to the country's island status and the lack of conventional energy resources. The Vice Ministry of Energy Security and Infrastructure, in keeping with its mission of establishing policies to guarantee electric power service for the Dominican population, is working on a National Indicative Plan for the Development of Critical Energy Infrastructures. PI Ramón Emilio De Jesús-Grullón was the main external assessor and editor for the Plan.

2.5 Indicative Plan for Critical Energy Infrastructure (Report for Vice Minister of Security and Energy Infrastructure (VSEI))

After months of research, consulting, and reviewing, the Indicative Plan for the Development of Critical Energy Infrastructure was delivered to the Vice Minister of Security and Infrastructure, Fausto Pérez, to later be sent to the Minister of Energy, Antonio Almonte on December 20, 2021.

For the external consulting process, the draft plan was sent to the state institutions involved: Dominican Electricity Transmission Company (ETED), a state electricity company whose objective is to operate the National Interconnected Electric System (SENI) to provide high voltage electric power transport services to the entire national territory, National Energy Commission (CNE), the institution in charge of designing the policy for the Dominican State in the Energy Sector and the Coordinating Body (OC), which mission is to coordinate the operation of the national interconnected electricity system for a safe and reliable energy supply, at a minimum cost and determine economic transactions, in accordance with the regulations, with an interdependent organization and effective use of resources. Hundreds of comments and doubts were received and filtered to finish the draft.

2.6 OpenDSS-Based Distribution Network Analyzer in Open-Source GIS Environment Implementation in EDENORTE (VOLG101).

The ongoing work is focused on solving the technical challenges that have arisen when transcribing EDENORTE's information, contained in the Geographical Information System (GIS), to the OpenDSS terminal.

In order to reduce complexity and to address the current challenges, while also testing the software capabilities and flexibility, the selected distribution networks have been reduced significantly and split into 21 different polygons containing around 7,000 clients. For example, figure 1 contains only 306 loads, which significantly reduces the complexity of the simulation allowing the modelers to look for errors more quickly.



Fig 1 - Polygon 1 out of 21 - VOLG 101 (306 Loads)

A great deal of effort is being invested to fix the software bugs and to increase the simulation output which will allow for further automation. Automating the process allows for faster development on future stages of project development and in terms of being able to transfer knowledge.

Q1 - January 2022 - March 2022

2.7 Initial results- OpenDSS-Based Distribution Network Analyzer in Open Source GIS Environment Implementation in EDENORTE (VOLG101).

The clearance of the initial obstacles and bugs in the data obtained from the local utility EDENORTE has been almost complete for all the polygons in which our sample circuit was divided. The process of unifying them will be conducted after individual testing is complete. Some of those polygons have already been tested and they are ready for power flow analysis.

2.8 Initial testing - OpalRT Real-Time Simulator

The first part of the training modules related to the use of the Opal RT real simulation environment has been taken. This activity required the configuration of the real time operating system installed in the simulator to establish communication between a high-performance virtual server executing Matlab/Simulink® in conjunction with RTLAB software. All the validation and required license installation have been completed and the first analog signals have been generated at the outputs of the simulator. Demo software has been executed in order to validate the correct functioning of the 5707XG Opal RT simulator.

The training was divided in four sessions:

- Introduction to HIL simulation with RTLAB software
- Definitions for HIL simulation and how RTLAB software integrates with Matlab/Simulink®. Installation of licenses and the update of the firmware for the real time simulator.
- Matlab/Simulink® compiling and real time simulation
 - Loading Matlab/Simulink® demo models into the real time simulator using RTLAB and executing the real time simulation. The monitoring tools for the simulation and the timing requirements were reviewed.
- Preparing Matlab/Simulink® simulations for HIL simulations with RTLAB
 - A model was developed from scratch in order to understand the required organization of a Matlab/Simulink® model for its execution in the real time simulator. The capability of multicore simulation was explored and the integration between RTLAB PanelView and Matlab/Simulink® graphical user interface.
- Digital and Analog Inputs/Outputs with 5707XG simulator
 - The FPGA coprocessor of the real time simulator was configured and digital and analog inputs/outputs were tested.

Section 3 - Stakeholder Events

URL: <https://docs.google.com/spreadsheets/d/1-jhLI4FDo1Zpi6REQ4DJxMX-qV8FDZtD/edit?usp=sharing&ouid=114062573798093444243&rtpof=true&sd=true>

Q1 - April - July (2021)

The MG Research Team organized two events, one workshop/outreach event presenting the project's vision, goals, and lines of research. This first event was organized in collaboration with the IEEE subsection in the Dominican Republic. The team has also organized a seminar series on Smart Cities, where we had the honor to have professionals and academics from across the region. The event focused on several topics regarding the importance of technology and innovation in the future of cities, and where we presented a panel on microgrids with experts from academia in the region.



Smart Cities
Promoviendo la Innovación y Adaptación Tecnológica en la República Dominicana

IEEE Dominicana junto al Comité de Estudiantes de Ingeniería Mecánica y Eléctrica e Island Innovation tiene el honor de presentar una serie de charlas técnicas relacionadas a Smart Cities, con el objetivo de promover y propiciar la innovación y adaptación tecnológica en nuestro país.

Viernes 16 de Julio	Sábado 17 de Julio	PANEL
Aplicaciones del Machine Learning El Rol del Machine Learning en las Ciudades Inteligentes. Guillermo Ballester - Freyrie Tech, España Las ciudades inteligentes tienen como objetivo gestionar de manera eficiente la creciente urbanización, el consumo de energía, mantener un entorno verde, mejorar los estándares económicos y de vida de sus ciudadanos y aumentar la capacidad de las personas para utilizar y adoptar de manera eficiente la tecnología moderna de la información y la comunicación.	Energía Mini-Eléctrica Urbana Potencial, retos y futuro Alexander Vallejo - INTEC, Rep. Dominicana Las instalaciones eléctricas de pequeña potencia presentan una característica propia, que las dota de una serie de ventajas adicionales respecto a la gran red, como una potencial mayor eficiencia global por las pérdidas reducidas en las redes de transporte y distribución, y que permiten la integración de generación renovable sin necesidad de crear nuevas infraestructuras eléctricas.	Microrredes Eléctricas: ¿Es la descentralización el futuro de la energía? Rafael Barrios - PUCMM Abraham Espinal - PUCMM Pablo Andrade (PHL) - UPRM Félix Santos (PHL) - INTEC
Gemelos Digitales Explorando aplicaciones y oportunidades Ben Weber - Star Weber & Energy, España Los Gemelos Digitales (Digital Twins) son un puente entre el mundo físico y el digital, un punto de interacción entre el conocimiento de los datos y la toma de decisiones basada en ellos. A medida que se conectan "cosas" más complejas, este puente se fortalece y permite que en la actualidad esté ocurriendo una revolución industrial completamente nueva y, en el proceso, abriendo las puertas de la innovación.	Ciudades Hiperconectadas Como el Internet de las Cosas (IoT) está creando nuevas oportunidades Gustavo Valverde (PHL) - Universidad de Costa Rica El IoT está generando una revolución en el sector energético, apoyando la transición hacia las energías renovables de varias formas, incluida una mejor supervisión, operación y mantenimiento de los activos de energía renovable; operaciones del sistema más refinadas y control más cercano al tiempo real; implementación de nuevos diseños de mercado; y la aparición de nuevos modelos comerciales.	Fechas + 16 de julio 2021 + 17 de julio 2021
Redes Urbanas de Refrigeración Beneficios y Oportunidades Edoardo Segredo - THERMAG, Rep. Dominicana En las condiciones adecuadas, la refrigeración urbana puede ofrecer numerosas ventajas sobre los sistemas de refrigeración convencionales al agotar la demanda de aire frío en áreas urbanas densas, la refrigeración de distrito es más rentable a largo plazo que las opciones de refrigeración convencionales a nivel de edificio individual.	Microrredes de Generación Renovable en redes de baja tensión Dr. Félix Santos (PHL) - CEETA, Cuba Miguel Aybar - INTEC, Rep. Dominicana Debido al aumento de eventos extremos provocados por el clima, la mejora de resiliencia de las redes eléctricas es hoy el centro de atención de sectores como gobierno, industria, investigación e ingeniería. Las microrredes han surgido como una herramienta para hacer frente a estos eventos debido a su potencial de recuperarse de manera rápida y efectiva, y a la capacidad de mantener la creciente penetración de las fuentes de energía renovable.	Evento Virtual -Llenar formulario de registro (Eventbrite) -Zoom Webinar (Transmisión) -Reto (Networking and Q&A)
		Institución + Pontificia Universidad Católica Madre y Maestra (PUCMM)



Con el objetivo de dar a conocer, despertar el interés por la investigación sobre la Resiliencia Energética, y conectar con profesionales y estudiantes de nuestro país en busca de posibles oportunidades de colaboración, el IEEE Dominicana, junto con investigadores de la PUCMM, presenta diferentes conceptos y elementos técnicos referentes a las Microrredes frente a Eventos Climáticos en la República Dominicana.

La misma contará con los siguientes elementos:

- + Concepto y métricas de resiliencia,
- + Innovación: Uso de arquitectura Power Hardware in the Loop (PHIL) para la creación de un laboratorio de microrredes de última tendencia
- + Visión: Microrredes frente a eventos climáticos (segmentación de las redes de distribución)
- + ¿Cómo puedes colaborar?

Para más información, favor consultar nuestras redes sociales. Evento abierto a todo público.

¡Te esperamos!

Fecha:

15 de Junio 2021

Hora:

19:00 a 20:30

Lugar:

Via Zoom
(Llenar formulario)

Charlistas

Ramón Emilio De Jesús
Abraham Espinal
Rafael Batista

Institución

Pontificia Universidad Católica Madre y Maestra



Fig 2 - Q1 - April - July (2021) events

URL: [Panel sobre Microrredes Eléctricas - Seminario Smart Cities \(2021\) PUCMM](#)

Q2 - July - October (2021)

The MG Research Team organized two events, one workshop titled: *“Modeling and Simulation of Electrical Distribution Networks using OpenDSS and QGIS”* organized PI Ramón E. De Jesús and CI Abraham Espinal, where the team showed an introduction to one of the main tools being developed and utilized in the research: *a software add-on (plugin)* that creates the OpenDSS network model directly from an open-source GIS software environment (QGIS2OpenDSS - developed by a research laboratory in the University of Costa Rica) and that exponentially reduces modeling time to simulation time.

The other workshop titled *“Introduction to Matlab & Simulink for the Analysis of Electrical Power Systems”* was organized by CI Rafael Batista. The workshop reviewed the fundamental concepts for the application of the tools offered by the Matlab / Simulink® suite and focused on the study of electrical power systems.



Workshop: Introducción a Matlab & Simulink® para el Análisis de Sistemas Eléctricos de Potencia.

La característica dinámica de los sistemas eléctricos de potencia propone retos importantes a la hora de obtener simulaciones que agreguen valor a los procesos de diseño y planificación de los sistemas eléctricos interconectados. Adicionalmente, la creciente inclusión de generación distribuida requiere de técnicas avanzadas que permitan estudiar la estabilidad del sistema considerando distintos escenarios de operación. Matlab/Simulink® ofrece una serie de librerías que permiten facilitar este proceso de análisis y diseño.

El taller revisará los conceptos fundamentales para la aplicación de las herramientas ofrecidas por la suite Matlab/Simulink® enfocadas en el estudio de sistemas eléctricos de potencia. El contenido a desarrollar busca ser un punto de partida para la utilización de Matlab/Simulink®, agolando la siguiente agenda:

- Introducción al ambiente Matlab® y el lenguaje de programación M.
- Estructuras de datos y bloques funcionales de programación.
- Implementación de análisis numérico.
- Introducción a Simulink® e integración con el ambiente de trabajo de Matlab®.
- Uso de la librería Simscape Electrical para el análisis de sistemas de potencia.

Fecha:
Sesión 1: Jueves 14 de Octubre del 2021
Sesión 2: Lunes 01 de Noviembre del 2021

Hora:
19:00 a 20:30

Lugar:
Via Zoom (Llenar formulario)

Charlistas:
Rafael Batista

Institución
Pontificia Universidad Católica Madre y Maestra (PUCMM)

Para más información, favor consultar nuestras redes sociales. Evento abierto a todo público.

¡Te esperamos!



Workshop: Modelado y Simulación de Redes de Distribución Eléctrica usando OpenDSS y QGIS

Para evaluar y estudiar el impacto de tecnologías disruptivas como sistemas fotovoltaicos, sistemas de almacenamiento y vehículos eléctricos en redes de Media Tensión y Baja Tensión, es necesario contar con herramientas avanzadas de simulación y modelos detallados de la Red de Distribución y sus componentes.

Los paquetes de software como Open Distribution System Simulation (OpenDSS) son herramientas de código abierto con técnicas de modelado avanzadas y capacidades informáticas de alto rendimiento que pueden manejar fácilmente cientos y miles de segmentos de línea de MT y BT; sin embargo, los resultados de la simulación de estos softwares dependen en gran medida de la calidad y disponibilidad de los datos de la red (tipo, tamaño y longitud de los conductores o ubicación y capacidad de los transformadores de distribución) que normalmente se almacenan en el GIS de las empresas eléctricas.

En este workshop introductorio hablaremos de OpenDSS y de un complemento de software (plugin) que crea el modelo de red OpenDSS directamente desde un entorno de software GIS de código abierto (QGIS2OpenDSS), lo que reduce exponencialmente el tiempo de modelado al tiempo de simulación.

Fecha:
Sesión 1: Lunes 11 de Octubre del 2021
Sesión 2: Miércoles 13 de Octubre del 2021

Hora:
19:00 a 20:30

Lugar:
Via Zoom (Llenar formulario)

Charlistas:
Ramón Emilio De Jesús-Grullón
Abraham Espinal Serrata

Institución
Pontificia Universidad Católica Madre y Maestra (PUCMM)

Para más información, favor consultar nuestras redes sociales. Evento abierto a todo público.

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Fig 3 - Q2 - July - October (2021) Webinars: (Left) “Introduction to Matlab & Simulink for the Analysis of Electrical Power Systems” & (Right) Modeling and Simulation of Electrical Distribution Networks using OpenDSS and QGIS”

Q3 - October (2021) - January (2022)

The MG Research Team organized two webinars, participated in a Entrepreneurship Fair, and was invited to one specialized radio show and one TV Interview.

The first webinar was titled: ***“Enhanced Reliability and Resiliency for the DR Electric Grid: Microgrids”*** which was presented to the Puerto Rico and Caribbean Power and Energy Society (PES), which consists of roughly 85 members including power engineering professionals, students, and associates in the Caribbean. The presentation was designed to showcase our ongoing research, the characteristics of the testbed, the stakeholders involved, the long-term vision and to open up collaboration opportunities.

The other webinar titled: ***“Microgrids against Climate-Driven Events in the DR”*** was presented to the USAID Mission in the DR: Erick Conde, Project Management Specialist, SEED Office, José Frank Cuello, our STIP specialist, Aneliya Nikolova, WASH specialist, and Brenda Silverio, Communication specialist



Webinar: Enhanced Reliability and Resiliency for the DR Electric Grid: Microgrids



Webinar: Microgrids against Climate-Driven Events in the DR.

Objective:

This webinar will showcase and externalize the research objectives focused on energy resilience in the DR with the intention of connecting with professionals and students within the IEEE PES Puerto Rico and Caribbean Networks in search of possible opportunities for collaboration.

Content:

1. Objectives
 - 1.1 Modelling and Simulation of LV and MV Networks
 - 1.2 Hardware-in-the-Loop Microgrid Testbed
2. Stakeholders
 - 2.1 Regional Utility (EDENORTE)
 - 2.2 Vice-Ministry of Energy and Security
 - 2.3 Microgrid Researchers (University of Puerto Rico Mayaguez, University of Montana)
3. Long term Vision
 - 3.1 Minigrids and Grid Segmentation
4. Collaboration Opportunities
 - 4.1 Capacity Building
 - 4.2 Knowledge Transfer

Date:
Tuesday 16 of December 2021

Time:
19:00 a 20:30

Online:
Via Webex (Llenar formulario)

Speakers:
Ramón Emilio De Jesús-Grullón
Abraham Espinal Serrata

Institution
Pontificia Universidad Católica Madre y Maestra (PUCMM)

For more information, please consult our social networks. Event open to all public.

¡Te esperamos!

Resiliency Analysis for the Development of Microgrid Architecture against Climate-Driven Events in the Dominican Republic's Electric Systems, being developed by the professors and researchers Ramón Emilio De Jesús (PI), Rafael Batista (CI), and Abraham Espinal (CI), from the School of Mechanical and Electrical Engineering of the Pontificia Universidad Católica Madre y Maestra (PUCMM). The research is part of the Partnerships for Enhanced Engagement in Research (PEER) implemented by the National Science Foundation, one of the winning projects from an application pool of over three thousand with an approved budget of USD \$ 159,066.

The objectives of the project are designed so that the results are a technical and regulatory route to build resilience against the extreme effects of climate change specifically to the Dominican Republic energy infrastructure, with the vision of translating our findings to other island nations.

Date:
Monday 15 of November 2021

Time:
11:00 a 11:30

Online:
Zoom Webinar

Speakers
Ramón Emilio De Jesús-Grullón

Institution
Pontificia Universidad Católica Madre y Maestra (PUCMM)





Fig 4 - Q3 - October (2021) - January (2022) Webinars: (Left) “Enhanced Reliability and Resiliency for the DR Electric Grid: Microgrids” Power Systems” & (Right) Microgrids against Climate-Driven Events in the DR”

Section 4 - Research Team

Additional Research Team Information



Juan José Pichardo Estévez is a senior student at the “Pontificia Universidad Católica Madre y Maestra (PUCMM)” in Santiago, Dominican Republic. He is currently pursuing a degree in Electrical Engineering with a concentration in Electrical Power Systems (Expected to finish in 2022). Before entering PUCMM, Pichardo graduated from high school in 2018 at the “Instituto Leonardo Da Vinci” obtaining a technical degree in informatics. Apart from his academic studies, Juan José is also a musician, and has been part of PUCMM’s music group “Tuna Universitaria” as a percussionist and drummer.

Section 5 - Educational Impacts

5.1 Training Activities

Development of training courses on OpenDSS and Matlab/Simulink

The main platforms/software to simulate the electrical grid components and interactions have been already identified by the team, and training courses on how to utilize them will be developed to build capacity among the students and professionals that interact with the project. This will serve as a platform for developing future work and investigations. The team will organize workshops on the use and capabilities of these two tools for developing Power Systems simulations and to address studies on specific electrical grid issues. The training courses and workshops will be held at PUCMM with the support of the Engineering faculty and student's committee. Furthermore, these training courses will help the integration of future students into the project as well as serving as a base for the development of the engineering curriculum of the local universities.

Development of training courses on QGIS and OpenDSS integration

The integration of OpenDSS and QGIS has been crucial in order to have the capability to represent the existing large distribution networks and its components in the scripting language of the OpenDSS software. There are several plugins available under the QGIS stack that help correct and filter the information prior to its translation into the scripting language, therefore a course on these special plugins will be very convenient to be linked to the previous OpenDSS course, giving it a broader applicability.

5.2 Coursework Impact

The activities that have been developed so far in the project have had impact in the future planning of the capstone projects that will be assigned in the department of Electrical Engineering. Various research lines related to Microgrid development have been selected as priority for capstones projects. Specifically, these capstone projects are related to the use of OpenDSS for DC Microgrid evaluation and the technical assessment of the implementation of a HVDC transmission between Dominican Republic and Puerto Rico. It is clear that both capstone projects will take advantage of the simulation environment provided by the test bed in development under this project and the know-how that has been acquired related to electrical utility simulations with microgrid integration under OpenDSS.

Furthermore, the equipment purchased for the laboratory may have extra uses related to courses in control systems and power electronics, and the curriculum is being evaluated to integrate these tools on those courses.

Section 6 - Research Outputs

Microgrid Research Blog

URL: <https://microgridresearchpucmm.blog/>

A Website/Blog was created to share the project vision and to externalize results

The blog serves as a channel of thought and as a support to publicize the project and to attract students and collaborators, in addition it works as an excellent presentation letter and summary of the status of the investigation. It will be linked to PUCMM's *Vicerrectoría de Investigación* (VRI) website and will have a blog section that will be updated regularly and will be linked to social networks profiles to increase the visibility of the site and the results.

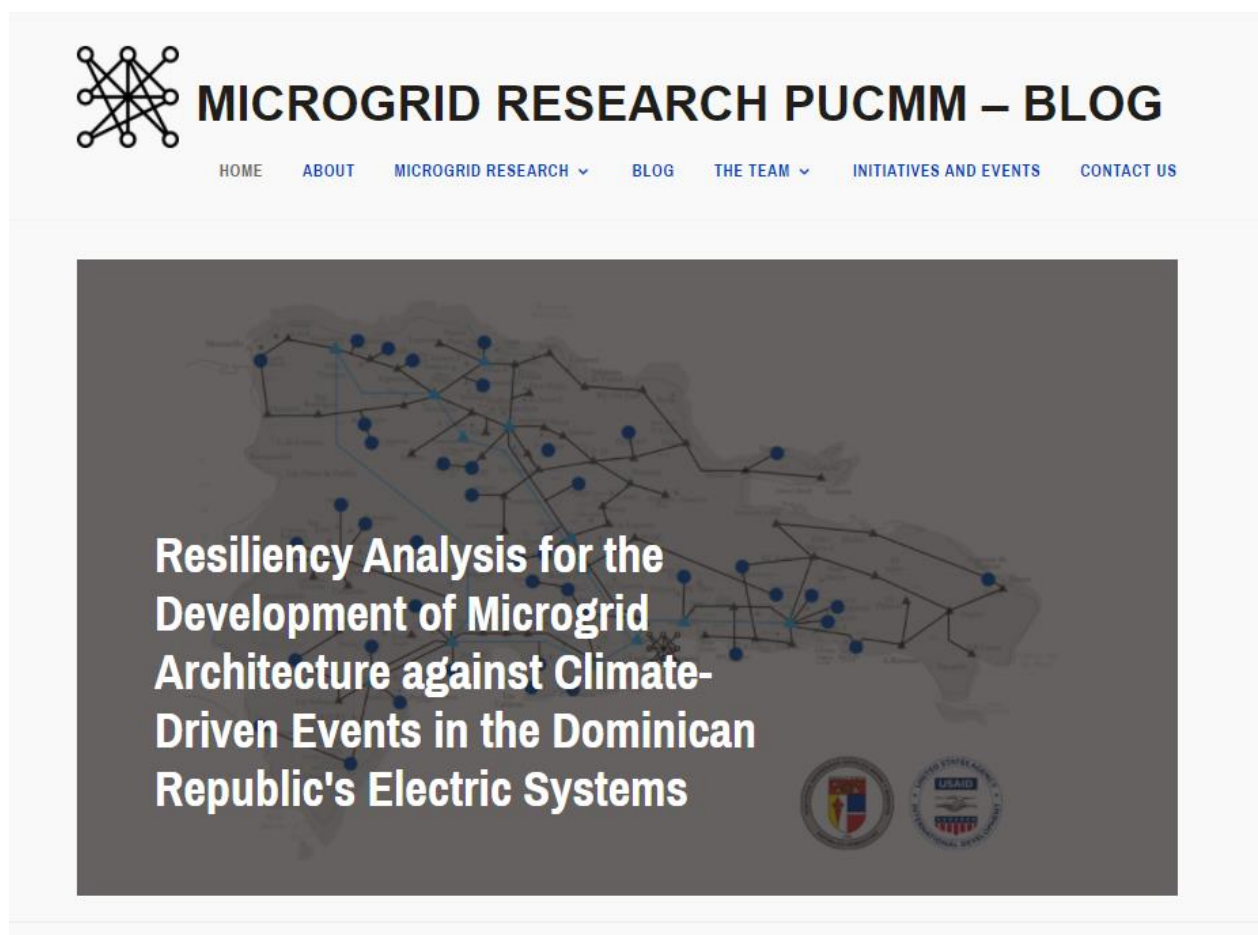
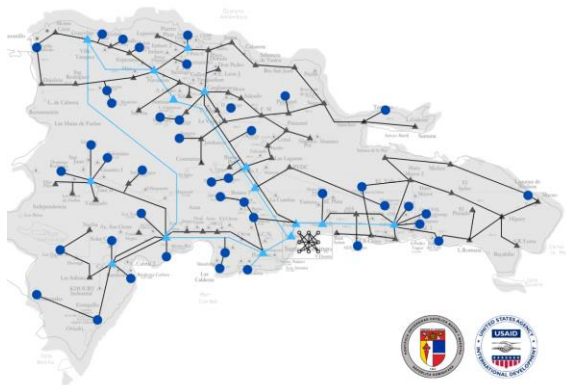


Fig 5. Microgrid Research PUCMM Landing Page

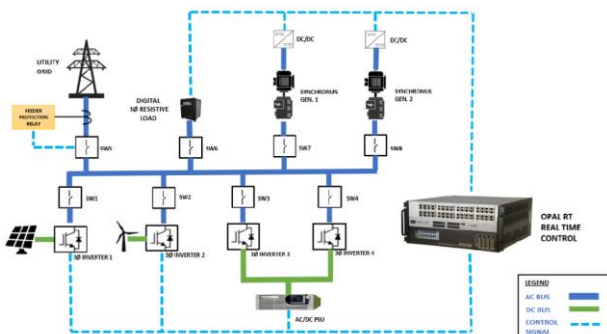
6.2 Research Outputs (not peer-reviewed)



Blog Entry 1 (October 12, 2021) | Towards the Future: The 21st Century Electric Grid

In this blog PI De Jesús laid out the basic principles of his vision on the future of energy, touching on the transactive Grid: Decarbonization, Decentralization, and Digitization, and how it's self-evident we are on the verge of the energy shift that our societies will experience in the coming decades and what need to be done to be part of that transformation in our day-to-day.

URL: <https://microgridresearchpucmm.blog/2021/10/12/towards-the-future-the-21st-century-electric-grid/>



Blog Entry 2 (November 11, 2021) | Hardware-in-the-Loop Simulation and its Impact on the Design of Power Systems

CI Batista talks about a key technology that we will implement in the Microgrid Testbed: Hardware-in-the-Loop (HIL).

The mission of the PUCMM Microgrids Laboratory is to be a reference for the formulation of improvements in the electrical grid system. Paving the way for policies which aim to enhance the resiliency and the efficiency of Dominican Republic's national electrical grid system.

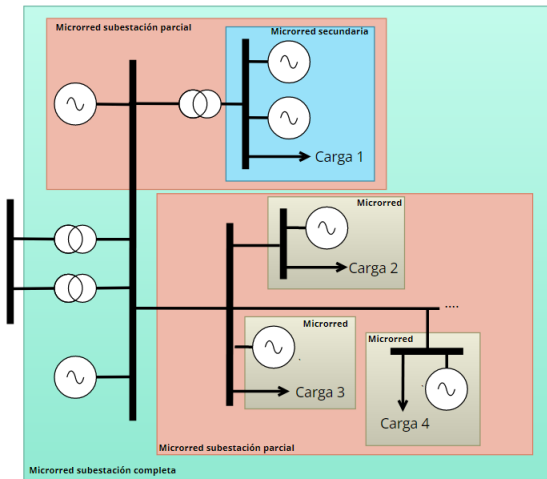
URL: [Hardware-in-the-Loop Simulation and its Impact on the Design of Power Systems – Microgrid Research PUCMM](https://microgridresearchpucmm.blog/2021/11/11/hardware-in-the-loop-simulation-and-its-impact-on-the-design-of-power-systems-microgrid-research-pucmm)



Blog Entry 3 (January 11, 2022) | Energy Transition and Challenges in the Post COVID Era

CI Espinal highlights the current situation of the ongoing energy transition and the present challenges based on three waves of disruption (Decentralization/Decarbonization, Energy Storage and Electromobility). It also addresses how the pandemic, that continues to affect the world, has changed the outlooks and time estimates on the milestones to be accomplished and on what the future holds for a rapidly changing energy sector.

URL: <https://microgridresearchpucmm.blog/2022/01/11/energy-transition-and-challenges-in-the-post-covid-era/>



Blog Entry 4 (TBR March 25, 2022) | Networked Microgrids: Building blocks of the SmartGrid

In this soon to be released entry, CI Batista makes a point in the significance of a decentralized scheme for the modern electrical utility. This decentralization will rely fundamentally in the implementation of borderless microgrids by the means of the concept of a networked microgrid. This blog entry will highlight the considerations that are under this concept of self forming microgrids inside a framework of a real time optimization problem. Furthermore, this entry will make the case of how networked microgrids will be the building blocks that are needed for accomplishing the objectives of the SmartGrid: Enhanced resiliency, manageable electrical market, cost reduction, and energy savings.

6.3 Technical Research Presentations

Q1 (2021) - Simulation of the Application of Electrical Resiliency Index in Dominican Republic Electrical Grid (MESCYT)

Under the framework of the Dominican's Republic Science and Investigation, the XVI International Scientific investigation Congress (CIC XVI) has been developed. The Congress is a space where scientific work and results of 350 projects are presented in order to promote the findings and create strategic alliance between investigators.

The goal was to show the importance of electrical power grid resilience measurements and enhancement, highlighting the additional pertinence it has on a centralized electrical power generation matrix, like the one we have in our country and how the resiliency indexes can be measured and further improved with the ongoing investigation we are carrying out.

A simulation of a critical load feeder of the main distribution/transmission electrical power substation in the north of the country has been accomplished. The selection was done based on the peculiarity of the circuits present in this feeder, including two of the largest health centers in the North Region of the country and one of the residential distribution circuits with the higher renewable energy penetration of the country (around 60%). The level of renewable penetration creates an attractive and relevant scenario for testing special conditions and possibilities of network configuration and adaptation during catastrophic events. The simulation was carried out on the software Matlab/Simulink®, where models of each element of the feeder were selected and parameterized according to details of the line diagram of the local interconnected electrical system (SENI). In order to measure and analyze the real state and resiliency of the selected feeder, line to ground and line to line faults simulations were carried out on the different circuits of the selected feeder. The results provide a better understanding and allow researchers to assess protection coordination and control strategies for the improvement of the resiliency in these critical circuits.

State of the art electrical distribution and transmission systems resiliency indexes were shown, highlighting pros and cons of the different available models and how they are

measured. Operational and infrastructure resilience approaches were presented and defined, focusing on the definition of the indexes and their mathematical expressions. Resilience indexes based on level of service and probabilistic loss of service of the electrical grid were presented as well as the fragility curve of circuit elements associated with meteorological parameters such as wind speed under a Montecarlo fault simulation scheme. Resilience enhancement strategies were presented addressing both infrastructure and operational resilience behavior of the electrical grid through the increase of the robustness of the physical grid and the application of microgrid formation control strategies.

With the simulation of the fault conditions it was shown that the topology of the network and characteristics of the circuit can play a significant role on how the protection of the circuits and feeders can be affected.

Further work on simulating substation protection relays and the effect of short circuit currents in the different fault types needs to be done in order to assess the control strategies to be carried out for microgrid formation by the grid segmentation and islanding condition, as well as distributed generation inclusion. In order to correctly quantify the results of the strategies implemented, the resiliency indexes to be used need to be measured with the initial conditions and after proposed control strategies are put into action based on protection behavior and tripping circuit effects on the grid topology.

URL: [Acceptance Letter.docx](#)

6.4 Peer-reviewed Publications and Proceedings*

Currently, work is in progress to present a research publication related to the use of evolutionary optimization techniques for the reconfiguration of a simulation model for networked microgrids. This simulation model is based on a benchmark system for networked microgrid control strategies evaluation, the optimization constraints that are being included are: critical load, minimization of distributions losses, and achieving generator's technical constraints. There is currently high interest in these kinds of approaches, and the combination of resiliency, operational, and economical constraints evaluated in this benchmark is a novel approach.

Section 7 - Personal Development

7.1 IEEE PES

The team is joining IEEE with a professional membership. IEEE is the leading professional association for the advancement of technology. With more than 400,000 members in more than 160 countries, IEEE is the world's largest technical professional society. Through its global membership, IEEE is a leading authority on areas ranging from aerospace systems, computers and telecommunications to biomedical engineering, electric power, consumer electronics, and many other technical areas.

7.2 Puerto Rico and Caribbean Power and Energy Society (PES)

PI Ramón Emilio De Jesús was officially invited to be the Young Professionals and Women in Engineering Liaison for the IEEE PES Innovative Smart Grid Technologies – Latin America (IEEE PES-ISGT LA) 2023 Proposal.

The 2023 ISGT is being heavily geared towards the renewable generation and smart grid industries and the Local Organizing Committee (LOC) has already engaged and gauged the interest of more than 15 companies, with very strong positive feedback. The industry will showcase their technological developments, as well as providing panel presentations, industrial-focused papers, keynote talks, and financial support. Finally, government institutions will be able to provide updates on current regulatory issues. As of December 2021, the LOC has reached out to the main engineering colleges and universities. The University of Puerto Rico (UPR), University Anna G Mendez (UAGM) and Interamerican University (IUPR) have shown interest. The LOC has contacted and is awaiting confirmation from at least two additional institutions: Polytechnic University of Puerto Rico (PUPR) and Turabo University (UTPR). The LOC has also invited Puerto Rico Energy Bureau (PREB), the energy/utility regulator, which has also shown interest in participating. Finally, we have reached out and are expecting responses from industry participants. Communications have been sent to Hitachi/ABB, General Electric, Mitsubishi, and Sweitzer Engineering Laboratories (SEL).

URL: [EOI-ISGT-2023-PRCS R0 \(1\).pdf](#)

7.3 Island Innovation's Virtual Island Summit

Ramón Emilio De Jesus, PI, Joined a network of 10,000 islanders from around the world as a speaker and ambassador at the #VirtualIslandSummit from Island Innovation. Under Unite Behind The SC1.5NCE - an Intergenerational Dialogue on the Future of Islands, PI De Jesús shared his experience as a researcher as well as in the Island Innovation network and Ambassador program, and how he thinks it shaped and helped create change on the island, as well as how it influenced Ramon and his colleague Miguel H. Estévez S. to create Embajadores de Energia at Energía Journal RD.

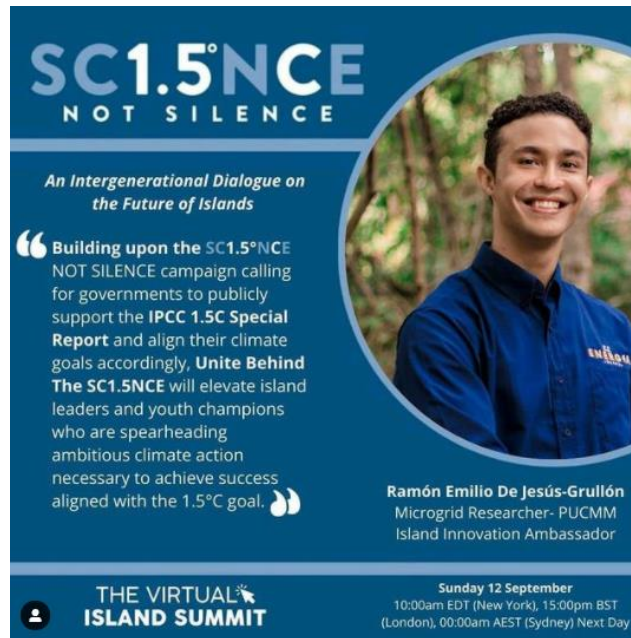


Fig 6 Virtual Island Summit – United Behind Science International Dialogue. Pi Ramón Emilio De Jesús Banner

URL: [VIS2021 - Unite Behind The SC1.5NCE, an Intergenerational Dialogue on the Future of Islands - Se...](#)

7.5 Center for Development and Industrial Competitiveness (PROINDUSTRIA)

PI De Jesús was invited to participate in the first Entrepreneurship and Innovation Fair of the Center for Industrial Development and Competitiveness - ProIndustria, held in the city of Santiago de los Caballeros, Dominican Republic.

An Abstract of the Microgrid Research was showcased for a heterogeneous public, including Governmental Officials (Andres Cueto, General Manager of EDENORTE) Universities (Father Secilio Espinal Espinal, recently appointed as rector of the Pontifical Catholic University Mother and Teacher (PUCMM)) and citizens.



Fig 7- Entrepreneurship and Innovation Fair of the Center for Industrial Development and Competitiveness - ProIndustria. (left) Father Secilio Espinal (PUCMM's new Rector. (right) Ing. Andres Cueto, General Manager of EDENORTE.

7.6 Adelante RD | Canal 4RD

PI De Jesús was invited to participate in Esta Mañana, a national TV show, with the intention of communicating the vision of not only the research project on Resiliency and Microgrids, but also other ventures that share the same vision Stor Water and Energía Journal RD. In the segment called AdelanteRD, presented by the Charys Melo and Alex Santiago, the founders talked about their vision, exploring the importance and relevance of the Water-Energy Nexus for Dominican Republic, and to transmit the desire to work with the Dominican state providing institutions such as the Corporación De Acueductos Y Alcantarillados De Santiago (CORAASAN) and EDENORTE, SA, the necessary tools to accelerate their digitization.

URL: [Esta Mañana| Ramón Emilio De Jesús y Miguel H. Estévez. Co-founder](#)



Fig 8- TV Interview at Channel4RD

7.8 Energías, Combustibles y Más | Radio program specialized in Energy and Fuels for the DR | ZOL 106.5 FM

PI De Jesús was invited to participate in a national radio show Energías, Combustibles y Más, a segment specialized in Energy and Fuels, broadcast by zol1065fm FM every Tuesday at 8.30PM. In this space, along with his colleagues from other ventures (Stor Water and Energia Journal), PI De Jesus talked about their trajectory, vision, and projects in development, such as:

- Research on Energy Resilience and Microgrids (Implementation Project with EDENORTE, Microgrids Laboratory)
- Energia Journal: Portal to the most relevant of the world of energy and sustainability in the Dominican Republic.
- Stor Water: Data Analysis and Digital Twins for the water sector.



Fig 9- Energías, Combustibles y Mas Radio Show - ZOL1065FM

URL: [Ben Weber y Ramón Emilio de Jesús nos comentan sobre Resiliencia Energética y Microredes](#)

7.9 Q1 - January - March (2022) – Discussion Panel

The MG Research Team organized one webinar, was invited to an specialized radio show, and was invited to National Renewable Energy and Sustainability Summit.

The Webinar was titled: Energy 4.0 - The Future of Energy in the Dominican Republic, which was presented to an heterogenous group of professionals, students and faculty from across the DR. The Webinar was hosted by EGRESADOS PUCMM, which is a non-profit organization, committed to the growth and strengthening of the services offered by the Pontificia Universidad Católica Madre y Maestra to students.

URL: [Panel - Energía 4.0: El Futuro de la Energía en República Dominicana](#)

Panel virtual

Energía 4.0:

El Futuro de la Energía en República Dominicana

Panelistas:

- Ing. Ramón De Jesús
- Ing. Rafael Batista
- Ing. Abraham Espinal

10 de febrero de 2022 6:00 p. m. Zoom: link in bio

Moderador:
Ing. Carlos Pantaleón
Director de la Escuela de Ingeniería Eléctrica

Logos: Pontificia Universidad Católica Madre y Maestra, Fundación Mundo y Maestra, Inc., Egresados PUCMM

Fig 10 - Energy 4.0 - The Future of Energy in the Dominican Republic

7.10 Specialized Radio Show - Energías Combustibles y Mas - National Energy Plan (2022-2036)

In this segment, Ramón Emilio De Jesús Grullón (PI) exposes the central ideas about the National Energy Plan (2022-2036). The objective of the PEN (2022-2036) is to present the current condition of the Dominican energy sector, while outlining its future development, based on the vision of energy policies from both the public and private sectors, in favor of a system Optimum energy at a technical and, above all, economic level.



Fig 11 - Energy 4.0 - The Future of Energy in the Dominican Republic

URL: [Ramón Emilio De Jesús Grullón: Plan Energético Nacional](#)

7.11 Energías, Combustibles y Más | Radio program specialized in Energy and Fuels for the DR | ZOL 106.5 FM

CI Abraham Espinal was invited to participate in a national radio show Energías, Combustibles y Más, a segment specialized in Energy and Fuels, broadcast by zol1065fm FM every Tuesday at 8.30PM. A debate was established regarding a change in regulation for distributed renewable energy integration, CI Espinal talked about how increasing the distributed generation (DG) in combination with the application of control strategies can increase the resilience of the Electrical Grid (EG) and why it is important to continue promoting it. Three main points related to the implementation of DG were highlighted:

- Increased resilience over High impact Low Probability events
- Better behavior to climate variability
- First steps toward a more modern intelligent EG.



Fig 12- Energías, Combustibles y Mas Radio Show – ZOL1065FM

URL: [Debate sobre Generación Distribuida con el de equipo energía combustible y más Parte 1/2](#)

7.12 Renewable Energies and Sustainability Forum

Researchers from the Pontificia Universidad Católica Madre y Maestra represented the university at the “1st Meeting for a Sustainable Energy Transformation” forum, an activity organized by the Sustainable Energy Forum, within the framework of World Efficiency Day. This forum, held in the context of the Official Development Agenda Santiago 2030, aimed to publicize the protagonists of the Energy Transition in the country, as well as their plans, decisions and impact on the economy and the environment.

Ramón Emilio De Jesús Grullón and Rafael Batista, research professors from the School of Mechanical and Electrical Engineering of La Madre y Maestra, gave the keynote address Interconnected Microgrids: Improving Resilience in Electrical Grids in the Dominican Republic.

URL: <https://ritmoeconomico.com/especialistas-urgen-la-implementacion-de-la-transicion-energetica-en-rd/>



Fig 13 - Renewable Energies and Sustainability Forum

7.13 Specialized Radio Show - Energías Combustibles y Mas – Water Crisis and Our Ageing Infrastructure – Water Day

In this segment, Ramón Emilio De Jesús Grullón (PI) talked the water crisis, and her sister infrastructure crisis. De Jesús talked about his most recent article that covered our current relationship with water from an historical point of view, touching on topics such as the Illusion of Abundance of the resource, DayZ eros (when cities run out of water) , the Complexity of the Water Use Worldwide (personal, agricultural, industrial use), the problem of Our Ageing Infrastructure, and closed with a case study from what is needed to solve one of the simplest issues: water leakages (the low hanging fruit) with an example of new regulation in California, USA.

URL: [https://youtu.be/ eeKzD5hklo](https://youtu.be/eeKzD5hklo)

Section 8 - Outreach and Potential Development (Abril 2021 - March 2022) - HIGHLIGHTS

Government Agencies

8.1 EDENORTE (Empresa Distribuidora de Electricidad del Norte)

Q1 - April 2021 - July 2021

EDENORTE and the MG Research Team created a working group in order to map out and translate the existing Network Topology in a Geographical Information System (QGIS) to be able to use it to Model and Simulate the network in Open Distribution System Simulator (OpenDSS).

Q3 - October 2021 - January 2022

In order to reduce complexity and to address the current challenges, while also testing the software capabilities and flexibility, the selected distribution networks (VOLG101 Feeder) have been split into 21 different polygons containing around 7,000 clients. The working group created a procedure to reduce the connection tolerance of the load distribution through a manual connection in OpenDSS.

Figure 14 showcases how the distribution of loads looks like before the manual correction (left), and how it looks like after (right)



Fig 14 - Manual correction of load distribution on QGIS

8.2 VSEI (Viceministerio de Seguridad Energética e Infraestructura)

National Indicative Plan for Critical Energy Infrastructure

The VSEI's new administration is now mapping the Critical Energy Infrastructure in the country, creating an Indicative Plan on how to enhance resiliency across the whole system. PI Ramón Emilio De Jesús-Grullón is the main external assessor and editor for the Plan. The Plan is derived from an extensive investigation on the effects of Hurricanes María and Irma (2017) on the Energy Infrastructure of Puerto Rico, and draws conclusions from the recommendations made by agencies of the United States Government (e.g. US Department of Energy) and Laboratories such as Rocky Mountain Institute (RMI) to the government of Puerto Rico: PREPA (Puerto Rico Electric Power Authority) and Puerto Rico Energy Commission (PREC), as well as the vision of the Critical Infrastructure Risk Management Framework taken from the National Infrastructure Protection Plan (NIPP) of the United States Government, and of the literature in Energy Infrastructure Risk Management of U.S. Department of Energy Office of Energy Assurance.

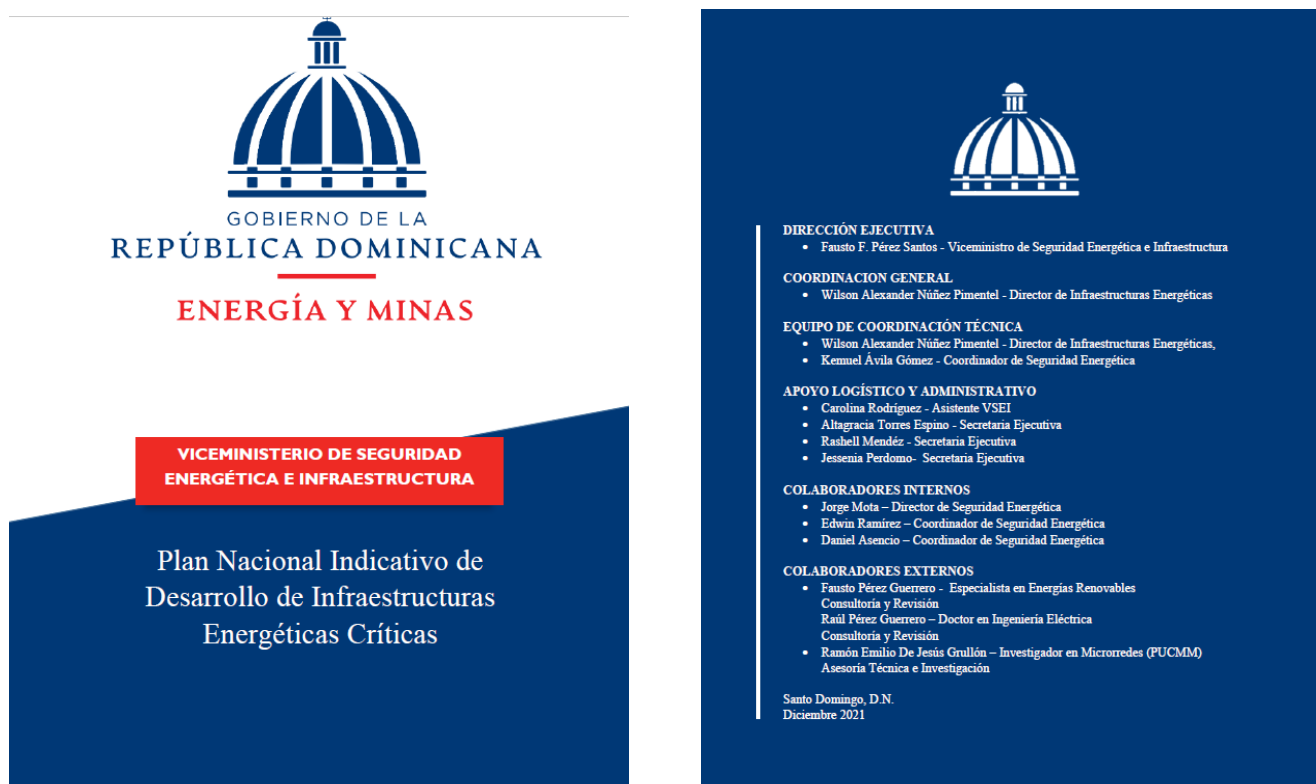


Fig 15- National Indicative Plan for Critical Energy Infrastructure

URL: [PIEC_v\(20-12-2021\).pdf](#)

8.3 National Energy Commission (CNE) - Q2 - July 2021 - October 2021

The research team contacted CNE's Alternative Sources and Rational Use of Energy Director, Ing. Yeulis Rivas, to present the research project and to discuss Critical Energy Infrastructure, as well as the evolution of the Energy Transition Project, led by *Deutsche Gesellschaft für Internationale Zusammenarbeit* (GIZ) GmbH together with 17 other partners from the energy sectors and climate in the country. The objective is to support the climate and energy sectors of the Dominican Republic to develop actions aimed at a low-carbon economy through the promotion of renewable energies.

Non-Governmental Organizations

8.4 Universidad de Costa Rica (UCR)

Researchers at the UCR are working and building state-of-the-art plugins and co-simulations environments between GIS systems and OpenDSS (Open Distribution System Simulator). The research team at UCR have provided access to 3 plugins, manuals, and research papers that are reducing the construction of Distribution Models by a substantial order of magnitude (from months to weeks).

8.5 Puerto Rico and Caribbean Power and Energy Society (PES)

PI Ramón Emilio De Jesús was officially invited to be the Young Professionals and Women in Engineering Liaison for the IEEE PES Innovative Smart Grid Technologies – Latin America (IEEE PES-ISGT LA) 2023 Proposal.

URL: [EOI-ISGT-2023-PRCS R0 \(1\).pdf](#)

8.6 INTEC (Instituto Tecnológico de Santo Domingo).

CI Rafael Batista is continuing his doctoral formation as a result of networking activities promoted by this project. His doctoral thesis work is going to be fundamental in the formation of networked microgrid systems and the use of optimization techniques for the evaluation of automatic decision rules in the dynamic formation of microgrid systems. This research topic is related and of importance regarding the implementation of our proposed electrical resiliency enhancement algorithms.

8.7 Collaboration with Madre y Maestra Foundation

C.I Abraham Espinal, through his company (ENESTAR), has made agreements to donate scholarships and equipment to the School of Electrical and Mechanical Engineering and the Microgrid and Renewable Energy Laboratory of the University for an estimated value of USD\$20,000.00.



Fig 16. ENESTAR signed an agreement for a scholarship and donation program with the Fundación Madre y Maestra

Between the equipment donated were Grid monitoring Protection Relay, Wind and Solar power generation systems, Energy Storage systems, Testing equipment and specialized design software, which will be used as part of the microgrid testbed that is developed in the PEER project.

URI:: [Enestar y Fundación Madre y Maestra firman acuerdo](#)

Private Companies

8.8 ENESTAR - Development of a MicroGrid in Sabana Real, Independencia

C.I Abraham Espinal, through his company (ENESTAR), has made won a Bidding process to develop in conjunction with the GIZ, Minister of Energy and Mines (MEM) and local utility EDESUR a microgrid for a remote town, right in the border of the country with Haiti, with an estimated value of USD\$300,000.00. Further collaboration with the research team and these institutions is going to be set for load and grid control strategies study and implementation in an already working MicroGrid.



Fig 17. ENESTAR won a bidding for the development of a Microgrid in a remote community.

8.9 EATON

EATON, a manufacturer of electrical equipment with local production, was contacted to strengthen relations and offer the laboratory and research resources for the creation of inter-institutional agreements. EATON was interested both in equipment donation and in collaboration for its research and development department, and the conversation is kept open waiting on them to finish a new Engineering location in Santo Domingo that is under construction.

Potential Development Impacts (Evidence to Action)

Use of developed tools by EDENORTE

The research tools being developed alongside the utility personnel will be applied immediately by the Technical Management of Distribution Network Planning and Study in their daily operations. The knowledge derived from this experience will help us to create the conceptual and information maps necessary to interact with the other distribution utilities in the country, thus reducing the learning curve and barriers to entry.

Joint training activities are being planned between EDENORTE's technical team and MG Research Team in order to teach students the tools that the regional utility uses to carry out network studies.

Capacity building in the DR Government (Vice Minister of Security and Energy Infrastructure)

With the invitation to participate in the creation of the Indicative Plan of the Vice Ministry of Security and Energy Infrastructure, the researchers are already influencing state policy on energy resilience. In the report conclusion and recommendations (*see executive summary in annexes*), two sections have been dedicated to Selective Segmentation in Transmission and Distribution and to Microgrids, both important theses of the research. The recommendations are described as essential to the energy resiliency of the island and vital information to start its study and implementation is provided.

Capacity building in Energy Education

The project is strengthening in-country research capacity by involving a broader group of students and local researchers. By using the existing IEEE Student Network, the researchers are now connecting with students from across the country intending to offer consultancy and insights about the project, making tools, manuals, and information open to them using our blog.

PI De Jesús is also working to create an outreach channel using the Energía Journal's Energy Ambassador program to externalize the results of the research to the Spanish language.

Capacity building in Research

The final setup of the first Hardware in the Loop (HIL) lab, the first available in the country, will enable future research on Electrical Grids related topics. Taking into account that the procedures for setting up the HIL lab are being documented and could be used as guidelines for other research projects implementation.

The preparation of the designated space, equipment location, and installation is being performed in parallel. Training in the use and understanding of the HIL lab equipment is

being scheduled and we are promoting the project so that related fields professors and assistants can be a part of the further stages.

Please describe in what way your data or research was used to inform a policy or program

The VSEI's new administration is now mapping the Critical Energy Infrastructure in the country, creating an Indicative Plan defining how to enhance resiliency across the whole system. PI Ramón Emilio De Jesús-Grullón is the main external researcher and editor for the Plan.

See section **8.1 VSEI (Viceministerio de Seguridad Energética e Infraestructura)**

The National Plan is organized as follows:

- **Section 2: Introduction**
- **Section 3: Overview of the Dominican Electricity Sector:** Current Status and Main Indicators
- **Section 4: SENI (National Interconnected Electric System) Vulnerabilities:** Describes the SENI structure and the cascading risks due to this structure.
- **Section 5: Critical Infrastructure Risk Management Framework:** Describes the objective and steps for designing a Risk Management Framework.

Objective: Increase the levels of reliability and supply of the energy to important infrastructure through the strategic planning of the development of new Critical Energy Infrastructures.

Methodology: The ultimate goal of the plan is to guide the national effort to manage different risks to the nation's critical infrastructure. To achieve this end in the medium term, national priorities must be collectively identified; articulate clear goals; mitigate risk; measure progress, and adapt based on feedback and the changing environment. Success in this complex endeavor draws on the full spectrum of capabilities, knowledge, and experience from a strong partnership between the institutions involved.

Scope: To achieve this objective and make recommendations and proposals, the following were analyzed:

- The Current Status of the National Interconnected Electric System (SENI)
- The current vulnerabilities of the SENI and the Catastrophic Risks for Network Security.
- A Risk Management Framework for Critical Energy Infrastructure

Section 9 - Additional Information

9.1 Problems Encountered

The main challenge so far has been the process of finding and fixing software bugs in the OpenDSS and QGIS plugins. This is mainly due to the high learning curve and the arduous process of cleaning the existing data from EDENORTE. Another important challenge in the medium term will be the creation of shared simulation environments between OpenDSS and MATLAB that remains crucial to the objectives of the research.

Regarding the purchase process of the lab equipment, the main challenges continues to be the current crisis affecting the supply chain and intercontinental shipping. Nevertheless, the manufacturing process of our two main critical components (OpalRT and Taraz Inverter) is completed and the shipping process is on the way. Right now, the main impact has been related to the Digital resistive load.

9.2 Ongoing research (3-6 months)

Testbed Integration

Currently the team is working on the preparation of the laboratory area for the placement and initial testing of the OPALRT real time control system. Network and protected electrical connections are currently being built. The initial validation will be done without the use of the inverters. The inverters are scheduled to arrive in the Dominican Republic in mid-January. The custom clearance process and tax exemption is expected to take about one month. Additionally, we are planning to test the DC power supply in January. We expect that the resistive digital load will be in the Dominican Republic by the end of January but will also have to go through the customs clearance process expected to take a months as well.

Co-simulation studies between OpenDSS and Matlab/Simulink/Python

The researchers will explore how RT-HIL systems improve the OpenDSS capabilities, interfacing the data delivered to the platform using analog and digital signals in Real Time (RT). The team will also explore DSS Python: The Unofficial bindings for EPRI's OpenDSS developed by researcher at University of Campinas (Unicamp), as well as Multi-Agent OpenDSS, an open source and scalable distribution grid platform developed by researchers at University of Central Florida.

Microgrid Research Program (Center)

Efforts have been made in contacting other researchers in PUCMM interested in topics related to the transition to SmartGrids and the inclusion of renewable energy distributed generation. The possibility of creating a research group focused on this topic and the integration of the research initiatives in a single laboratory in order to optimize budget and research capabilities is being studied.

Additional Comments

Research Assistant

SUMMARY OF COMPLETED TASKS (OCTOBER-DECEMBER 2021)

Date submitted	Completed tasks
6-November-2021	QGIS model error correction (VOLG101 Polygons 19-22)
21-December-2021	QGIS model revision (VOLG101 Polygons 1-6)

TASKS DETAILS:

- **QGIS model error correction (VOLG101 Polygons 19-22):** Checking each load of the polygons 19, 20, 21, and 22 to correct the overlapped ones by manually separating them.

Objective: Reduce the overlapping loads simulation error on the VOLG101 QGIS model.

- **QGIS model revision (VOLG101 Polygons 1-6):** Checking the loads and LV conductors of the polygons 1, 2, 3, 4, 5, and 6.

Objective: Identify some of the possible causes of the errors that resulted in the OpenDSS/QGIS simulation. Additionally, the research assistant (Juan José Pichardo) is going to start an internship at EDENORTE where he will work with subjects that are relevant to this project.

Major Equipment Purchased

Status:

- **Opal RT:** The equipment is in PUCMM facilities, waiting for the connection to NETWORK and UPS systems.
- **Taraz Inverter:** The equipment expected arrival day is mid January. After this, it must complete the customs clearance process.
- **DC power supply:** The equipment is in PUCMM facilities; initial testing is being done.
- **Digital AC resistive load:** Purchase process completed, awaiting for arrival at the end of January.
- **LOAD CENTER:** Equipment is in PUCMM facilities, initial validation of the interconnection as required in the quotation has been done.

9.3 Additional Research Grant Details

We have not received any additional grant in this period, but we are currently doing the due diligence to request a grant from the National Fund for Innovation and Scientific and Technological Development, managed by the Ministry of Higher Education, Science and Technology, to extent one of the research lines.

URL: <https://mescyt.gob.do/fondocyt/>

ANNEX - Attachments-Financial Report-Year 1